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RATIONAL DISTRIBUTION OF THE THERMAL LOAD ALONG A GLASS-MELTING TANK

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The experience of the Borsk Glass Factory showed that one of the significant factors for improving the efficiency of a tank glass-melting furnace is rational distribution of the total gas consumption over the burners. Recommendations for further improvement of the technical and economic parameters of furnace operation are given.

The glass-melting furnace is the main technological unit in the production of polished sheet glass. The main processes of glass melting and melt heat treatment take place here, and the quantity and quality of manufactured glass largely depend on the efficiency of these processes.

Of great importance is the thermal homogeneity of glass melt in its movement from the melting zone to the glass-molding machines. A most significant factor of thermal homogeneity is optimization and stability of the technological parameters of the glass-melting process.

A decisive factor that determines the rate of silicate and glass formation, the clarification process, and the chemical homogeneity of the glass melt is the stability of the thermal conditions of the furnace. At the same time, our industrial experience established that the optimum gas distribution over the melting-tank burners plays a special role. A rational scheme of thermal-load distribution along the glass-melting tank is a prerequisite to improving the furnace efficiency.

A team of researchers[2] at the Borsk Glass Factory developed a new, improved regime of gas-consumption distribu-

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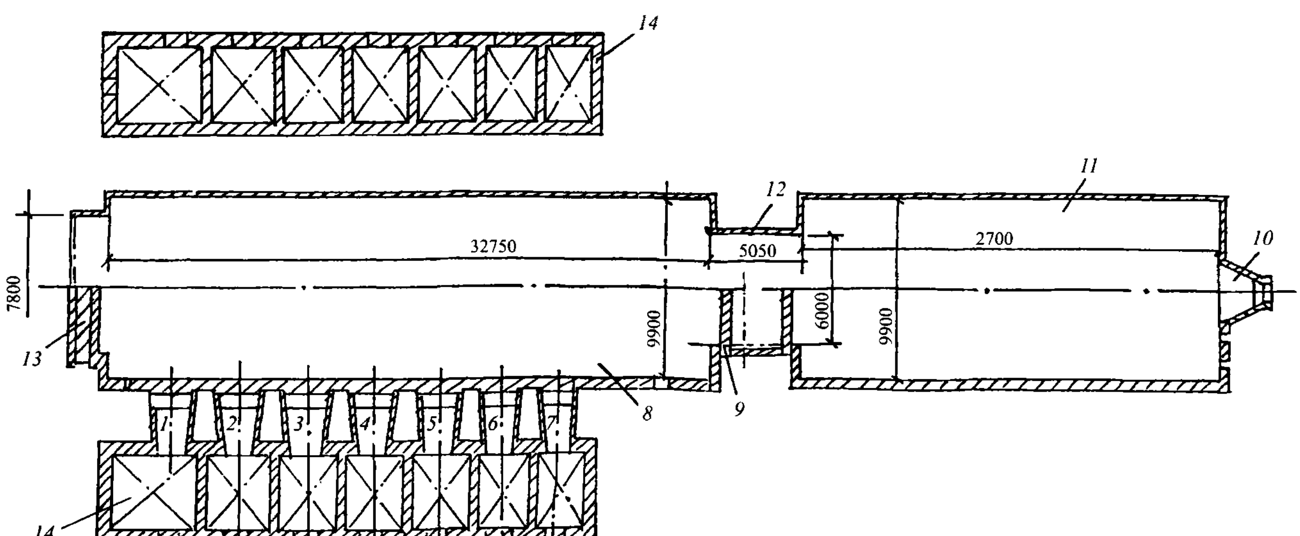

Fig. 1. Diagram of the glass-melting furnace of the LPS-2 line for polished-glass production: *1* – *7*) furnace burners; *8*) melting zone; *9*) screen dividing the gas space of the melting and cooling zones; *10*) working channel; *11*) cooling zone; *12*) pinch; *13*) charge hopper; *14*) air regenerators.

tion over the burners of a glass-melting furnace, which was implemented in 1997 in shop No. 71 on the second float production line for polished glass (LPS-2).

Technical Characteristics of LPS-2

Line efficiency, ton/day. . . . . 390 – 600
Actual output in 1996, ton/day 450.5
Glass-melt capacity of the tank, tons. 1830
Melting-zone dimensions (length, width, depth), m
. . . . 32.75 × 9.9 × 1.4
Surface area, m^2:
of the melting zone up to the pinch 320
of the melting zone up to the end of the 7th burner. . 261
of the cooling zone 225
Dimensions (length, width, depth), m:
of the charging hopper . . . . 1.95 × 7.8 × 1.4
of the pinch. . . . . 5.05 × 6.0 × 1.1
of the cooling zone. . . . . 22.7 × 9.9 × 1.1
of the float tank. . . . . 61 × 7.2
Gas consumption, m^3/h . . . . 4600 – 5200
Specific heat consumption under maximum output, kJ/kg (kcal/kg) 7746 (1850)
Maximum specific glass-melt output, kg/m^2 per day . 2300

The drawing in Fig. 1 represents the glass-melting furnace of the LPS-2 line. The basic parameters of the thermal loads along the furnace length are given in Table 1. They characterize furnace operation both before (under a traditional thermal load) and after implementation of the new thermal regime, i.e., a more rational distribution of the thermal load.

The furnace has been in service since 1986, and for many years the traditional temperature conditions were employed here (Fig. 2), under which the furnace output amounted to 480 ton/day with a total gas consumption for all burners equal to 4845 m^3/h.

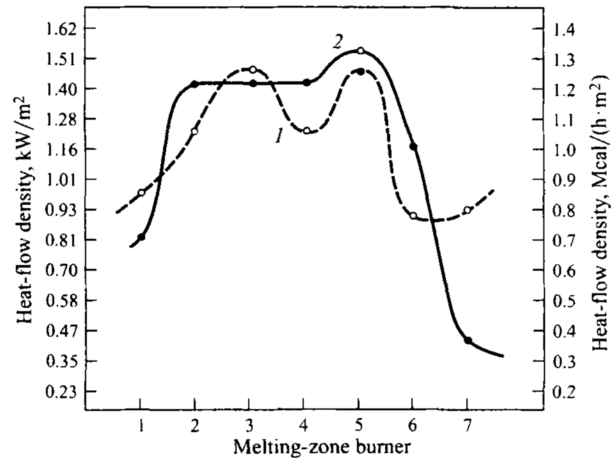

Fig. 2. Heat-flow distribution along the furnace melting zone before implementation (*1*) and after implementation (*2*) of the new regime.

The largest amount of gas was fed to the 3rd and 5th burners, which are located a distance of 10 and 17 m, respectively, from the end wall of the charge hopper. The maximum temperatures here reached 1580°C.

The heat-flow density along the melting-zone length is shown in Table 1. The specific heat consumption is 8059 J/kg, or 1926 kcal/kg, and the specific glass-melt output in the melting zone is 1872 kg/m^2 per day.

The output of glass products at the factory in 1997 increased by 14% compared to 1996. As the demand for the products keeps growing, the factory plans to reach full capacity by the year 2000. The most important challenge for the factory is to lower the production cost per unit product and to bring the product quality to the international-standard level.

TABLE 1

Parameter	Thermal load of the burners						
	1	2	3	4	5	6	7
Gas-consumption distribution recommended by the operating regulations, %	16 – 18	18 – 19	20 – 21	20 – 21	12 – 13	6 – 8	3 – 4
Gas consumption, m^3/h:							
before implementation	834	718	856	718	804	468	448
after implementation	668	804	810	810	822	586	200
Gas-consumption distribution, %:							
before implementation	17.7	148	17.7	14.8	16.6	9.7	9.2
after implementation	14.2	17.1	17.2	17.7	17.5	12.5	4.2
Heat-flow density, $\frac{\text{kW/m}^2}{\text{Mcal/(h}\cdot\text{m}^2)}$:							
before implementation	$\frac{1.00}{0.85}$	$\frac{1.22}{1.05}$	$\frac{1.47}{1.26}$	$\frac{1.22}{1.05}$	$\frac{1.45}{1.25}$	$\frac{0.91}{0.78}$	$\frac{0.93}{0.8}$
after implementation	$\frac{0.81}{0.70}$	$\frac{1.42}{1.22}$	$\frac{1.42}{1.22}$	$\frac{1.42}{1.22}$	$\frac{1.52}{1.32}$	$\frac{1.17}{1.01}$	$\frac{0.43}{0.37}$

The most efficient way to reduce the specific production cost is to increase the production volume using the existing production space and machinery. Therefore, the problem of increasing the output and, foremost, the furnace efficiency is of special significance.

The most effective way to increase the specific output of glass melt is to increase the melting temperature. For sheet-glass furnaces each increase in melting temperature above 1550°C by 10°C increases the furnace efficiency by 4 – 7%. This effect is especially significant for highly efficient state-of-the-art furnaces, including the glass-melting furnace at the LPS-2 line.

An increase in the tank-furnace temperature improves the physicotechnical parameters of the glass as well as the furnace efficiency. Thus, as the melting temperature increases and the melt stays longer at the maximum temperatures, the glass-melt homogeneity and the physical and chemical properties of the glass are improved.

Table 1 and Fig. 2 present the traditional and new regimes of gas distribution over the burners and distribution of the heat-flow density along the melting zone for an initial furnace efficiency of 480 ton/day. Redistribution of the thermal energy among the 2nd, 4th, and 5th burners made it possible to decrease the gas consumption at the 1st and 7th pairs of burners.

The maximum-temperature region in this case coincides with the quelpunkt and is found at the middle of the melting tank: up to that place the temperature gradually grows, and after it, it keeps decreasing up to the working zone. The temperature decrease between the 5th burner (the maximum-temperature zone) and the 7th burner proceeds smoothly at a rate of 10 – 13°C/m. In the maximum-temperature region (the 4th-burner area) it becomes equalized. The extent of the melting zone under the new regime was equal to about half the melting tank.

The boundaries of the melting-foam zone became clearly defined, and secondary-foam sites were absent in the zone of the pure mirror of the melt. The overall fuel consumption at the first two pairs of burners amounted to 31.3%, and for the last two pairs it was 16.7% (Table 1). All this indicates rationally selected parameters of the furnace thermal conditions.

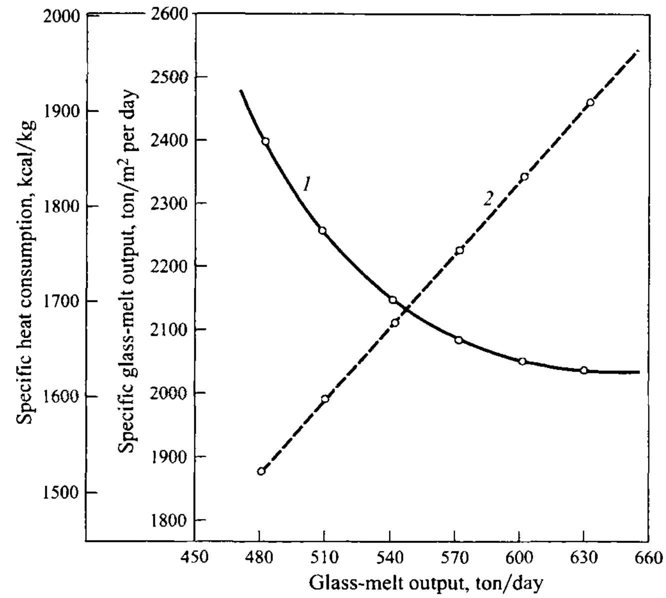

Fig. 3. Dependence of the specific heat consumption (*1*) and the specific glass-melt output (*2*) on the tank-furnace efficiency after implementation of the new conditions of the thermal-load distribution over the burners.

The new regime of gas distribution over the burners made it possible to increase the glass output of the furnace from 480 to 630 ton/day with a simultaneous decrease in the heat consumption from 8059 to 6841 J/kg (from 1926 to 1635 kcal/kg).

Table 2 and Fig. 3 present the dynamics of the decrease in the specific consumption of thermal energy and the increase in the specific output of glass melt.

TABLE 2

Efficiency, ton/day	Specific heat consumption, kJ / kg / kcal / kg	Decrease in heat consumption: kJ / kg / kcal / kg	Decrease in heat consumption: %	Specific glass-melt output, kg/m³ per day	Increase in glass-melt output: kg/m³ per day	Increase in glass-melt output: %
480	7821 / 1868	–	–	1872	–	–
510	7465 / 1783	339 / 81	4.32	1990	118	6.35
540	7126 / 1702	678 / 162	8.67	2106	234	12.50
570	6954 / 1661	850 / 203	10.86	2223	351	18.75
600	6866 / 1640	938 / 224	11.96	2340	469	25.05
630	6845 / 1635	958 / 229	12.96	2547	675	36.05

When an efficiency of 630 ton/day was attained, the temperature of the gas atmosphere in the furnace attained 1600°C. For a further increase in the efficiency of the glass-melting furnace the temperature would have to be increased above 1600°C, which is dangerous for dinas roof refractories. Therefore, there are two ways to increase the efficiency further: the use of higher-quality refractories and an increase in the area of the furnace melting zone.

Experience in industrial implementation of the new thermal regime indicated the existence of considerable reserves for improving the efficiency of glass-melting furnaces.